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Moving mathematics: Technology that changes teaching and learning

Mathematical activity can be seen as involving humans, mathematics and technology. While the role of technology in the discipline of mathematics itself is often ignored, Rotman's (2008) material-historical reading shows how mathematics has been involved in a two-way co-evolutionary relationship with machines since its inception. In the present, therefore, the dynamic technologies that are now available continue to shape mathematics as a discipline and, eventually, school mathematics too. While most educators would agree that humans are essentially dynamic, moving as they do through time and space, and that new technologies are as well, enabling as they do a manipulation of time (fast-forward, reverse, replay) and a morphing of objects (simulations, animations, etc.), the status of mathematics itself often remains unquestioned, unchanged, and quite static—in large part because of the long-standing domination of paper-and-pencil technology. In this talk, I argue that mathematics *is* dynamic and that its dynamicity is entrenched in a particular representational infrastructure that was alive in the pre-paper-and-pencil mathematics, and is newly alive now (see Schaffer & Kaput, 1999).

In this talk, I therefore make two claims: (1) Mathematical concept begin as mobile; (2) Mathematical concepts can be re-mobilised. Based on these claims, I also propose the following conjecture: Any mathematical concept worth teaching can be re-mobilised. It is possible to find evidence for the first claim by considering some of the ways in which mathematics has been defined. For example, Wheeler (2001) places generality, variance (and invariance) and infinity at the heart of mathematisation. In variance, the mobile dimension of mathematisation is most evidence. But it is also possible to understand the mobility of mathematics through a more theoretical approach. Indeed, as de Freitas and Sinclair (2014) argue, drawing on the new materialist perspectives of Karen Barad (2007) and the work of the philosopher of mathematics Gilles Châtelet (1996), mathematics is mobile precisely because it cannot be separated from humans and technologies; they are intra-related—they define each other. Châtelet attends specifically to issues of embodiment by focusing on the way that the moving hand (of the mathematician) creates gestures that are later captured in diagrams which in turn lead to mathematical formalisms. These diagrams capture the gesture "mid-flight" but retain the mobility of the hand in a way that the formal mathematics attempts to hide in its quest for detemporalisation.

Using this theoretical perspective, I analyse episodes of young children working in a dynamic geometry environments to explore triangles, parallel and perpendicular lines and symmetry (using Websketchpad files at www.sfu.ca/geometry4yl.html). These have been reported in Sinclair and Moss (2012); Sinclair, de Freitas and Ferrara (2013); and Ng and Sinclair (2015). In each case, I show how static concepts are re-mobilised through the dynamic geometry environment, which in turn engages the children in mathematisation around variance and invariance, which leads to generality and virtuality (extending to the infinite). Their ways of thinking about the concepts that emerge are bound to the dynamic technology, both in terms of the way the children speak and the way they gesture, which leads to new concepts that may differ in important ways from paper-and-pencil ones.

While the actual technology that is used in the analyses has been available for decades, it is the new theoretical approaches that enabled a different understanding of what the children are learning and, especially, what concepts they are creating in their interactions. The shift is thus ontological more than epistemological as we are recognising the evolving status of concepts themselves, and not just a different way of understanding pre-existing, static concepts.

References

Barad, K. (2007). *Meeting the universe halfway: Quantum physics and the entanglement of matter and meaning*. Durham: Duke University Press.

Châtelet, G. (2000). *Figuring space: Philosophy, mathematics, and physics* (R. Shore & M. Zagha, Trans.). Dordrecht: Kluwer.

de Freitas, E., & Sinclair, N. (2014). *Mathematics and the body: Material entanglements in the classroom*. Cambridge, UK: Cambridge University Press.

Ng, O. & Sinclair, N. (2015). Young children reasoning about symmetry in a dynamic geometry environment. *ZDM – The International Journal on Mathematics Education,* 51(3).

Rotman, B. (2008). *Becoming beside ourselves: The alphabet, ghosts, and distributed human beings*. Durham: Duke University Press.

Shaffer, D. W., & Kaput, J. (1999). Mathematics and virtual culture: A cognitive evolutionary perspective on technology and mathematics education. *Educational Studies in Mathematics*, 37(2), 97–119.

Sinclair, N. & Moss, J. (2012). The more it changes, the more it becomes the same: The development of the routine of shape identification in dynamic geometry environments. *International Journal of Education Research*, 51&52, 28-44.

Sinclair, N., de Freitas, E. & Ferrara, F. (2013). Virtual encounters: The murky and furtive world of mathematical inventiveness. *ZDM – The International Journal on Mathematics Education*, 45(2), 239-252.

Wheeler, D. (2001). *Mathematisation as a pedagogical tool. For the Learning of Mathematics*, 21(2), 50-53.